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EXAMINER

WOOD, WILLIAM H

ART UNIT

PAPER NUMBER

2124

DATE MAILED: 10/04/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

# Office Action Summary

Application No.

09/541,399

Applicant(s)

WU ET AL.

Examiner

William H. Wood

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

## Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

## Status

- 1) ☒ Responsive to communication(s) filed on 31 March 2000.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

## Disposition of Claims

- 4) ☒ Claim(s) 1-30 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-30 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

## Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 31 March 2000 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on \_\_\_\_\_ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

## Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
  - ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

## Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s). \_\_\_\_\_
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 2. 6) ☐ Other:

### DETAILED ACTION

Claims 1-30 have been examined.

#### ***Information Disclosure Statement***

1. The Information Disclosure Statement filed on 31 March 2000 has been considered.

#### ***Drawings***

2. The drawings submitted were approved by the draft person.

#### ***Claim Rejections - 35 USC § 102***

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

4. Claims 13, 15-16, 18-21 and 24-25 are rejected under 35 U.S.C. 102(b) as being anticipated by Muchnick, "Advanced Compiler Design Implementation", (pages 169-177).

In regard to claim 13, Muchnick disclosed the limitations:

*i) computer-implemented method of augmenting a control flow graph in support of hierarchical path profiling, the control flow graph having an outer region and an inner region (page 169, first paragraph, global indicates composing hierarchy of flow graphs as presented on page 177, Figure 7.8)*

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- ii) *identifying a representative entry node for the inner region* (page 172, section 7.1; in particular page 174, last two paragraphs)
- iii) *replacing the inner region with the representative entry node* (page 172, section 7.1; in particular page 174, last two paragraphs)
- iv) *for each prolog node of the inner region, adding an edge from the prolog node to the representative entry node* (page 172, section 7.1; in particular page 174, last two paragraphs)
- v) *for each epilog node of the inner region, adding an edge from the representative entry node to the epilog node* (page 172, section 7.1; in particular page 174, last two paragraphs)

In regard to claim 15, Muchnick disclosed the limitations:

- i) *creating a region source node of the outer region* (page 172, section 7.1; in particular page 174, last two paragraphs; page 177, Figure 7.8)
- ii) *for each entry node of the outer region, adding an edge from the region source node to the entry node* (page 172, section 7.1; in particular page 174, last two paragraphs; page 177, Figure 7.8)
- iii) *creating a region sink node for the outer region* (page 172, section 7.1; in particular page 174, last two paragraphs; page 177, Figure 7.8)
- iv) *for each exit node of the outer region, adding an edge from the exit node to the region sink node* (page 172, section 7.1; in particular page 174, last two paragraphs; page 177, Figure 7.8)

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In regard to claim 16, Muchnick disclosed the limitation *wherein the control flow graph includes a plurality of inner regions, and the actions of the method are applied for each of the plurality of inner regions, such that a different augmented control flow graph is created for each of the plurality of inner regions* (inherent, as profiling only one region would not give complete results).

In regard to claim 18, Muchnick disclosed the limitations:

- i) *method of augmenting a control flow graph in support of profiling a hierarchical path within a software function* (page 169, first paragraph, global indicates composing hierarchy of flow graphs as presented on page 177, Figure 7.8)
- ii) *identifying a representative path within an inner region of the software function, the representative path being identified by a representative entry node and a representative exit node* (page 177, Figure 7.8)
- iii) *for each prolog node of the inner region, adding an edge from the prolog node to the representative entry node* (page 172, section 7.1; in particular page 174, last two paragraphs)
- iv) *for each epilog node of the inner region, adding an edge from the representative exit node to the epilog node* (page 172, section 7.1; in particular page 174, last two paragraphs)

In regard to claim 19, Muchnick disclosed the limitations:

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- i) *removing any edges from prolog nodes of the inner region to entry nodes of the inner region other than the representative entry node (page 174, last two paragraphs and page 175, first paragraph)*
- ii) *removing any edges from exit nodes of the inner region other than the representative exit node to epilog nodes of the inner region (page 174, last two paragraphs and page 175, first paragraph)*

In regard to claim 20, Muchnick disclosed the limitations:

- i) *wherein the software function has a function entry and a function exit, and the inner region has at least one entry node and at least one exit node (page 169, first paragraph; page 177, Figure 7.8)*
- ii) *adding an edge from the function entry to each of the at least one entry node of the inner region (page 169, first paragraph; page 177, Figure 7.8)*
- iii) *adding an edge from each of the at least one exit node of the inner region to the function exit (page 169, first paragraph; page 177, Figure 7.8)*

In regard to claim 21, Muchnick disclosed the limitation *wherein the control flow graph includes a plurality of inner regions, and the actions of the method are applied for each of the plurality of inner regions* (inherent, as profiling only one region would not give complete results).

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In regard to claims 24 and 25, the limitations are substantially the same as the limitations of claims 18 and 20 and therefore rejected in the same manner here.

***Claim Rejections - 35 USC § 103***

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

6. Claims 1-12 and 26-30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ball et al., "Efficient Path Profiling" in view of Adl-Tabatabai (USPN 6,170,083).

In regard to claim 1, Ball disclosed the following limitations:

- i) initializing an inner path sum (Ball: Section 3, Path Profiling of DAGs)
- ii) summing edge values encountered in the inner region with the inner path sum (Ball: Section 3, Path Profiling of DAGs)
- iii) when exiting the inner region, modifying a profile indicator that represents the frequency of execution of a path within the inner region (Ball: Section 3, Path Profiling of DAGs)

Ball did not teach the limitations of having an inner and outer path sum and the hierarchical path profiler. Adl-Tabatabai demonstrated that it was known at the time of invention to divide path profiling into a hierarchical nature and thus have an inner and

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outer path sum (Adl-Tabatabai: Figure 5; column 4, lines 1-25; column 4, lines 26-50).

Furthermore, Adl-Tabatabai demonstrated *when entering an inner region, saving an outer path sum* (necessary for hierarchical code regions for returning after computing one nested level down) and *restoring the outer path sum* (necessary for hierarchical code regions for returning after computing one nested level down). It would have been obvious to one of ordinary skill in the art at the time of invention to implement Ball's efficient path profiling with hierarchy of inner and outer path sums as found in Adl-Tabatabai's teaching. This implementation would have been obvious because one of ordinary skill in the art would be motivated to provide an efficient profiling mechanism with the functionality of a popular programming language, Java, in order to produce better, faster programs.

In regard to claim 2, Ball and Adl-Tabatabai disclosed the limitation *wherein initializing an inner path sum comprises initializing the inner path sum to a value corresponding to an edge from a region source node to an entry node of the inner region* (inherent in Ball and Adl-Tabatabai's combination that a hierarchy of profiling would initialize a region (the inner path region) to the start of that region).

In regard to claim 3, Ball disclosed the limitation *wherein modifying a profile indicator comprises indexing into an array of profile indicators using the inner path sum* (Ball: page 47, first bulleted item).



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In regard to claim 4, Ball disclosed the limitation *wherein the array of profile indicators is dedicated to paths of the inner region* (Ball: taken alone indicates this in the fact that it only has one region, the inner most).

In regard to claim 5, Ball and Adl-Tabatabai disclosed the limitation *wherein initializing an inner path sum comprises initializing the inner path sum to a value corresponding to an edge from a function entry to an entry node of the inner region* (inherent in Ball and Adl-Tabatabai's combination that a hierarchy of profiling would initialize a region (the inner path region) to the start of that region).

In regard to claim 6, Ball disclosed the limitation *wherein modifying a profile indicator comprises indexing into an array of profile indicators using the inner path sum* (Ball: page 47, first bulleted item).

In regard to claim 7, Ball disclosed the limitation *wherein the array of profile indicators includes profile indicators corresponding to paths in the inner region and profile indicators corresponding to paths outside the inner region* (Ball and Adl-Tabatabia combo indicate this since a hierarchy of different profile paths now exist and therefore an array for all of them is now necessary).

In regard to claim 8, Ball disclosed the limitation *wherein the profile indicator includes a profile counter* (Ball: page 47, first bulleted item), *and modifying the profile indicator*

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*comprises generating a counter address as a function of the inner path sum (Ball: page 47, first bulleted item).*

In regard to claim 9, Ball disclosed the limitation *wherein the inner region includes a plurality of paths, each having an inner path sum corresponding thereto, the inner path sums corresponding to the plurality of paths in the inner region being unique relative to each other* (Ball: page 47, Section 1.1, Algorithm Overview).

In regard to claim 10, Ball and Adl-Tabatabai disclosed the limitation *wherein the inner region is one of a plurality of inner regions* (Adl-Tabatabai: Figure 5; column 4, lines 1-25), *and the inner path sums of the inner region are unique relative to inner path sums corresponding to other inner regions* (Ball and Adl-Tabatabai combo indicates this, without uniqueness profiling would have little use).

In regard to claim 11, Ball and Adl-Tabatabai did not teach *wherein saving an outer path sum comprises pushing the out path sum onto a stack*. Official Notice is taken that at the time of invention, it was known to implement structures of nesting, such as hierarchical structures, with pushing and popping from a stack a value of one level up or down. It would have been obvious to one of ordinary skill in the art at the time of invention to implement Ball and Adl-Tabatabai's profiling with a stack to push and pop the data of a previous level as was known in the art at the time of invention. This implementation would have been obvious because one of ordinary skill in the art would

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be motivated to save a separate and distinct value of a previous level for use when processing at the current level reached completion in order to enhance flexibility.

In regard to claim 12, Ball and Adl-Tabatabai did not explicitly teach the limitation *wherein restoring the outer path sum comprises popping the outer path sum from the stack*. Official Notice is taken that at the time of invention, it was known to implement structures of nesting, such as hierarchical structures, with pushing and popping from a stack a value of one level up or down. It would have been obvious to one of ordinary skill in the art at the time of invention to implement Ball and Adl-Tabatabai's profiling with a stack to push and pop the data of a previous level as was known in the art at the time of invention. This implementation would have been obvious because one of ordinary skill in the art would be motivated to save a separate and distinct value of a previous level for use when processing at the current level reached completion in order to enhance flexibility.

In regard to claims 26, Ball and Adl-Tabatabai disclosed the limitations:

- i) *computer-implemented method for instrumenting software in support of hierarchical path profiling*
- ii) *at an entry to an inner region, inserting an instruction to save an outer path sum*
- iii) *within the inner region, inserting instructions to sum edge values into an inner path sum*

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iv) *at an exit from the inner region, inserting an instruction to increment a counter addressed as a function of the inner path sum*

The rejection is the same as for claim 1 here since the limitations are the same.

In regard to claim 27, Ball and Adl-Tabatabai disclosed the limitation *at the exit from the inner region, inserting an instruction to restore the outer path sum* in claim 1. The rejection is the same.

In regard to claim 28, Ball and Adl-Tabatabai disclosed the limitation wherein the inner region is one of a plurality of inner regions in a hierarchical arrangement, and the actions of the method are applied to each of the plurality of inner regions (inherent, as profiling only one region would not give complete results).

In regard to claims 29 and 30, the limitations are the same as for claims 26 and 27 and therefore are rejected in the same manner.

7. Claims 14 and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Muchnick, "Advanced Compiler Design Implementation" as applied to claims 13 and 20 above, respectively, and in view of Ball et al., "Efficient Path Profiling".

In regard to claim 14, Muchnick did not explicitly teach the limitation *assigning edge values to all edges in the control flow graph such that the sum of the edge values along*

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*each unique path is unique within the control flow graph.* Ball demonstrated that it was known at the time of invention to assign edge values to produce a unique sum for each path (page 50, section 3.2). It would have been obvious to one of ordinary skill in the art at the time of invention to implement Muchnick's general knowledge of graphing systems with unique edge sum's for profiling as found in Ball's teaching. This implementation would have been obvious because one of ordinary skill in the art would be motivated to utilize well-known compiler theory with as efficient of a profiler as possible.

In regard to claim 23, Muchnick did not explicitly teach the limitation *assigning edge values to all edges in the control flow graph such that the sum of the edge values along each unique path is unique within the control flow graph.* Ball demonstrated that it was known at the time of invention to assign edge values to produce a unique sum for each path (page 50, section 3.2). It would have been obvious to one of ordinary skill in the art at the time of invention to implement Muchnick's general knowledge of graphing systems with unique edge sum's for profiling as found in Ball's teaching. This implementation would have been obvious because one of ordinary skill in the art would be motivated to utilize well-known compiler theory with as efficient of a profiler as possible.

8. Claims 17 and 22 are rejected under 35 U.S.C. 103(a) as being unpatentable over Muchnick, "Advanced Compiler Design Implementation" as applied to claims 15 and 20 above, respectively, and in view of Adl-Tabatabai (USPN 6,170,083).

In regard to claims 17, Muchnick did not explicitly state the limitation *wherein the control flow graph includes a hierarchy of inner regions, and the actions of the method are applied recursively to the hierarchy of inner regions, such that a different augmented control flow graph is created for each inner region in the hierarchy of inner regions*. Adl-Tabatabai demonstrated that it was known at the time of invention to construct a hierarchy of recursive code regions (column 4, lines 1-25). It would have been obvious to one of ordinary skill in the art at the time of invention to implement Muchnick's profiling with a hierarchy of recursive code regions as found in Adl-Tabatabai's teaching. This implementation would have been obvious because one of ordinary skill in the art would be motivated to implement code profiling with the ability to efficiently profile a popular programming language, Java.

In regard to claim 22, Muchnick did not explicitly state the limitation *wherein the control flow graph includes a hierarchy of inner regions, and the actions of the method are applied recursively to the hierarchy of inner regions*. Adl-Tabatabai demonstrated that it was known at the time of invention to construct a hierarchy of recursive code regions (column 4, lines 1-25). It would have been obvious to one of ordinary skill in the art at the time of invention to implement Muchnick's profiling with a hierarchy of recursive

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code regions as found in Adl-Tabatabai's teaching. This implementation would have been obvious because one of ordinary skill in the art would be motivated to implement code profiling with the ability to efficiently profile a popular programming language, Java.

9. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure as follows.

- a) Mataga et al., "Edge Profiling versus Path Profiling: The Showdown", taught general knowledge on path profiling.
- b) Young et al. "Better Global Scheduling Using Path Profiles", taught further knowledge on path profiles, including use throughout an entire program.
- c) Larus, "Whole Program Paths", taught an approach using Enhanced Path Profiles system of Ball and Larus to produce an entire programs profile. Specifically using graphs and optimizations very similar to applicants.
- d) Ammons et al. "Exploiting Hardware Performance Counters with Flow and Context Sensitive Profiling", taught the use of counters in profiling.
- e) Keller et al. (USPN 5,355,487) taught profile knowledge.
- f) Hall (USPN 5,828,883) taught call path profiles.
- g) Reps et al. (USPN 5,161,216) taught interprocedural graphs for global optimizations. The is applicable to claims creating a hierarchy of profiling.
- h) Bortnikov et al. (USPN 6,029,004) taught program modules in relation to profiling.

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- i) Larus et al. (USPN 6,327,699) taught whole program path profiling.
- j) Tenev et al. (USPN) taught manipulations of nodes in graph and tree representations.
- k) Gabzdyl et al. (USPN 6,145,076) taught the use of counters for hierarchical systems of processing. Especially applicable to claims regarding recursive activity.
- l) Aho, "Compilers: Principals, Techniques, and Tools", taught knowledge of flow graphs and flow graph manipulations at the time of invention. Aho disclosed, especially chapters 9 and 10 and in particular page 654, the concepts of arranging global optimizations in sections of flow control graphs having an entry node and an exit node. Applicant's claims regarding optimizations using flow graphs read upon Aho. Applicant's claims regarding flow graphs, path sums and profile arrays reads upon Aho in combination with Ball.


***Correspondence Information***

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to William H. Wood whose telephone number is (703)305-3305. The examiner can normally be reached 7:30am - 5:00pm Monday thru Thursday and 7:30am - 4:00pm every other Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kakali Chaki can be reached on (703)305-9662. The fax phone numbers for the organization where this application or proceeding is assigned are (703)746-7239 for regular communications and (703)746-7238 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703)305-3900.

William H. Wood  
October 1, 2002

  
**TUAN Q. DAM**  
**PRIMARY EXAMINER**